

U.S. Patent Application Serial No. 09/911,823
Amendment filed December 23, 2004
Reply to OA dated September 9, 2004

LISTING OF CLAIMS:

1 Claim 1 (original): A radio equipment changing antenna directivity on real time basis
2 and transmitting/receiving signals time divisionally to/from a plurality of terminals, comprising:
3 a plurality of antennas arranged in a discrete manner; and
4 a transmission circuit and a reception circuit sharing said plurality of antennas for
5 transmitting/receiving signals; wherein
6 said reception circuit includes
7 a reception signal separating unit for separating a signal from a specific terminal among
8 said plurality of terminals, based on signals from said plurality of antennas, when a reception
9 signals is received, and
10 a reception transmission path estimating unit estimating a reception response vector of a
11 propagation path from said specific terminal, based on signals from said plurality of antennas,
12 when said reception signal is received;
13 said transmission circuit includes
14 transmission propagation path estimating unit estimating a transmission response vector
15 of a transmission path when a transmission signal is transmitted, based on a result of estimation
16 by said reception propagation path estimating unit, and
17 a transmission directivity control unit updating said antenna directivity when said

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18 transmission signal is transmitted, based on a result of estimation by said transmission
19 propagation path estimating unit; and
20 said transmission propagation path estimating unit includes
21 an extrapolation processing unit calculating said transmission response vector of a down
22 link slot to said specific terminal, by an extrapolation process based on a plurality of said
23 reception response vectors of up link slots from said specific terminal estimated by said reception
24 propagation path estimating unit,
25 a memory holding a plurality of parameters used for said extrapolation process,
26 determined in advance in accordance with the propagation environment of said propagation path,
27 and
28 a selecting unit estimating the propagation environment of said propagation path,
29 selecting a parameter corresponding to said estimated propagation environment among said held
30 plurality of parameters, and applying the selected parameter to extrapolation process by said
31 extrapolation processing unit.

1 Claim 2 (original): The radio equipment according to claim 1, wherein
2 said parameter is an extrapolation distance in the extrapolation process by said
3 extrapolation processing unit, said memory holds a plurality of extrapolation distances
4 determined in advance in accordance with Doppler frequencies representing said propagation
5 environment, and said selecting unit estimates Doppler frequency of said propagation path,

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6 selects the extrapolation distance corresponding to said estimated Doppler frequency among said
7 held plurality of extrapolation distances and applies the selected extrapolation distance to the
8 extrapolation process by said extrapolation processing unit.

1 Claim 3 (original): The radio equipment according to claim 2, wherein
2 said selecting unit selects a shorter extrapolation distance when the estimated Doppler
3 frequency is lower, and selects a longer extrapolation distance when the estimated Doppler
4 frequency is higher.

5 Claim 4 (original): The radio equipment according to claim 1, wherein
6 said parameter is an extrapolation distance in an extrapolation process by said
7 extrapolation processing unit, said memory holds a plurality of extrapolation distances
8 determined in advance in accordance with a signal error between said separated signal and an
9 expected desired signal, which represents said propagation environment and
10 said selecting unit estimates signal error of said propagation path, selects the
11 extrapolation distance corresponding to said estimated signal error among said held plurality of
12 extrapolation distances and applies the selected extrapolation distance to the extrapolation
13 process by said extrapolation processing unit.

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1 Claim 5 (original): The radio equipment according to claim 4, wherein
2 said selecting unit selects a shorter extrapolation distance when the estimated signal error
3 is larger, and selects a larger extrapolation distance when the estimated signal error is smaller.

1 Claim 6 (original): The radio equipment according to claim 1, wherein
2 said parameter is an extrapolation distance in an extrapolation process by said
3 extrapolation processing unit, said memory holds a plurality of extrapolation distances
4 determined in advance in accordance with Doppler frequencies and a signal error between said
5 separated signal and an expected desired signal, which represent said propagation environment,
6 and said selecting unit estimates the Doppler frequency and the signal error of said propagation
7 path, selects an extrapolation distance corresponding to said estimated Doppler frequency and the
8 signal error among said held plurality of extrapolation distances and applies the selected
9 extrapolation distance to the extrapolation process by said extrapolation processing unit.

1 Claim 7 (original): The radio equipment according to claim 6, wherein
2 said selecting unit temporarily selects an extrapolation distance corresponding to said
3 estimated Doppler frequency, and corrects said temporarily selected extrapolation distance in
4 accordance with said estimated signal error.

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1 Claim 8 (original): The radio equipment according to claim 1, wherein
2 the relation between said propagation environment and said plurality of parameters is
3 determined individually for every said radio equipment.

1 Claim 9 (original): The radio equipment according to claim 1, wherein
2 the relation between said propagation environment and said plurality of parameters is
3 determined commonly to a plurality of said radio equipments.

1 Claim 10 (original): In a radio equipment changing antenna directivity on real time
2 basis and transmitting/receiving signals time divisionally to/from with a plurality of terminals, a
3 Doppler frequency estimating circuit estimating Doppler frequency of a propagation path with a
4 specific terminal, comprising:

5 a reception signal separating unit separating a signal from said specific terminal among
6 said plurality of terminals based on signals received by a plurality of antennas arranged in a
7 discrete manner;

8 a reception propagation path estimating unit estimating a reception response vector of a
9 propagation path from said specific terminal, based on signals received by said plurality of
10 antennas;

11 a correlation operating unit calculating a vector correlation value based on reception
12 response vectors preceding and succeeding in time estimated by said reception propagation path

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13 estimating unit; and
14 an estimating unit estimating a Doppler frequency corresponding to the vector correlation
15 value calculated by said correlation operating unit, based on correspondence between vector
16 correlation values and Doppler frequencies determined in advance experimentally.

1 Claim 11 (original): The Doppler frequency estimating circuit according to claim 10,

2 wherein

3 said correlation operating unit includes a calculating unit calculating an instantaneous
4 correlation value between said reception response vectors preceding and succeeding in time and
5 outputting calculated value as said vector correlation value.

1 Claim 12 (original): The Doppler frequency estimating circuit according to claim 10,

2 wherein

3 said correlation operating unit includes
4 a calculating unit calculating an instantaneous correlation value between said reception
5 response vectors preceding and succeeding in time, and
6 an averaging unit weight-averaging a past correlation value and a present correlation value
7 calculated by said calculating unit with a prescribed weight coefficient, and outputting an obtained
8 average value as said vector correlation value

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1 Claim 13 (original): The Doppler frequency estimating circuit according to claim 12,
2 wherein

3 said prescribed weight coefficient is set such that a weight for a past correlation value is
4 large and a weight for a present correlation value is small.

1 Claim 14 (original): The Doppler frequency estimating circuit according to claim 10,
2 wherein

3 said correlation operating unit calculates a vector correlation value based on a reception
4 response vector of a present frame slot and a reception response vector of an immediately
5 preceding frame slot.

1 Claim 15 (original): The Doppler frequency estimating circuit according to claim 10,
2 wherein

3 said correlation operating unit calculates a vector correlation value based on a reception
4 response vector of a present frame slot, and a reception response vector of a most recent slot free
5 of any reception error among past frame slots.

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1 Claim 16 (original): The Doppler frequency estimating circuit according to claim 10,
2 wherein

3 said correlation operating unit calculates a vector correlation value based on a reception
4 response vector of a former half and a reception response vector of a latter half of one slot.

1 Claim 17 (original): A radio equipment changing antenna directivity on real time basis
2 and transmitting/receiving signals time divisionally to/from a plurality of terminals, comprising:

3 a plurality of antennas arranged in a discrete manner; and
4 a transmission circuit and a reception circuit sharing said plurality of antennas for
5 transmitting/receiving signals; wherein
6 said reception circuit includes
7 a reception signal separating unit separating a signal from a specific terminal among said
8 plurality of terminals, based on signals from said plurality of antennas, when a reception signal is
9 received, and

10 a reception propagation path estimating unit estimating a reception response vector of a
11 propagation path from said specific terminal based on signals from said plurality of antennas,
12 when said reception signal is received;

13 said transmission circuit includes
14 a transmission propagation path estimating unit estimating a transmission response vector
15 of a propagation path when a transmission signal is transmitted, based on a result of estimation by

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16 said reception propagation path estimating unit, and
17 a transmission directivity control unit updating said antenna directivity when said
18 transmission signal is transmitted, based on a result of estimation by said transmission
19 propagation path estimating unit;
20 said transmission propagation path estimating unit includes
21 an extrapolation processing unit calculating said transmission response vector of a down
22 link slot to said specific terminal, by an extrapolation process based on a plurality of said
23 reception response vectors of up link slots of said specific terminal estimated by said reception
24 propagation path estimating unit,
25 a Doppler frequency estimating unit estimating a Doppler frequency of said propagation
26 path,
27 a memory holding a plurality of parameters used for said extrapolation process,
28 determined in advance in accordance with the Doppler frequencies of said propagation path, and
29 a selecting unit selecting a parameter corresponding to said estimated Doppler frequency
30 among said held plurality of parameters and applying the selected parameter to the extrapolation
31 process by said extrapolation processing unit; and
32 said Doppler frequency estimating unit includes
33 a correlation operating unit calculating a vector correlation value based on reception
34 response vectors preceding and succeeding in time estimated by said reception propagation path
35 estimating unit, and

36 an estimating unit estimating a Doppler frequency corresponding to the vector correlation
37 value calculated by said correlation operating unit, based on correspondence between vector
38 correlation values and Doppler frequencies determined in advance experimentally.

1 Claim 18 (original): The radio equipment according to claim 17, wherein
2 said correlation operating unit includes a calculating unit calculating an instantaneous
3 correlation value between said reception response vectors preceding and succeeding in time and
4 outputting the calculated value as said vector correlation value.

1 Claim 19 (original): The radio equipment according to claim 17, wherein
2 said correlation operating unit includes
3 a calculating unit calculating an instantaneous correlation value between said reception
4 response vectors preceding and succeeding in time, and
5 an averaging unit weight-averaging a past correlation value and a present correlation value
6 calculated by said calculating unit with a prescribed weight coefficient, and outputting an obtained
7 average value as said vector correlation value.

1 Claim 20 (original): The radio equipment according to claim 19, wherein
2 said prescribed weight coefficient is set such that a weight for a past correlation value is large and
3 a weight for a present correlation value is small.

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1 Claim 21 (original): The radio equipment according to claim 17, wherein
2 said correlation operating unit calculates a vector correlation value based on a reception
3 response vector of a present frame slot and a reception response vector of an immediately
4 preceding frame slot.

1 Claim 22 (original): The radio equipment according to claim 17, wherein
2 said correlation operating unit calculates a vector correlation value based on a reception
3 response vector of a present frame slot and a reception response vector of a most recent slot free
4 of any reception error among past frame slots.

1 Claim 23 (original): The radio equipment according to claim 17, wherein
2 said correlation operating unit calculates a vector correlation value based on a reception
3 response vector of a former half and a reception response vector of a latter half of one slot.

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